Vehicle Adapter for Notebook PCs

19 volts from a car battery

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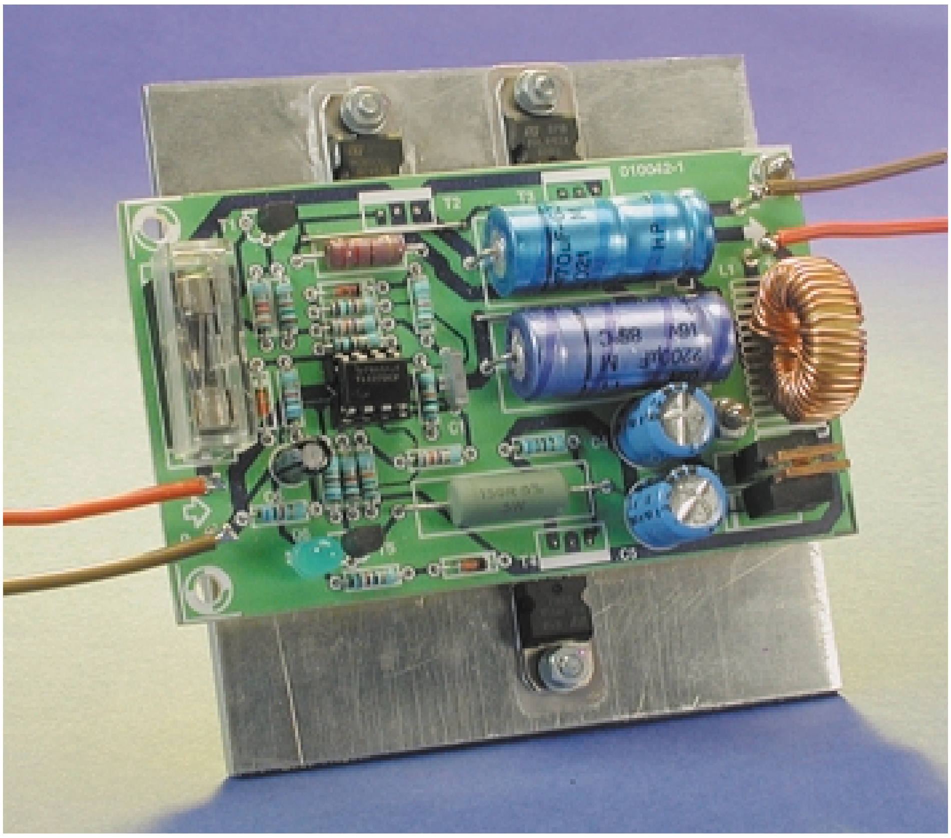
Notebook PCs are great but stray too far from a source of power and it's not long before low-battery warnings start to appear. Mains adapters come as standard but car adapters are expensive accessories. Good enough reason to get the soldering iron out!



Designs for switchmode power supplies or inverters always pose a problem for home constructors because they usually include inductive elements, transformers, chokes or ferrite cores that are difficult to procure. This dc-to-dc converter design uses just one standard inductor. In the prototype this inductor was part of the notebook's existing supply lead, here it is built onto the PCB.

This adapter design is suitable for notebooks requiring a dc input voltage in the range of 14 V to 19 V. It can provide a continuous current of 2 A with short duration peaks of around 2.5 A. The efficiency of the design is in the order of 60 to 80 % depending on the output voltage and current. A big advantage of this design is its low quiescent current of only 75 mA (more on this later).

The circuit diagram of the unit is shown in **Figure 1.** The operating principle is relatively simple. A free-running oscillator is used to drive a voltage doubler circuit. A voltage comparator controlling a series pass transistor regulates the output voltage. The input and output earth is common to the car earth potential.

The astable multivibrator is formed by IC1.B. Components C1 and R4 in the feedback path give an operating frequency of 15 kHz approximately. D1 and R7 ensure that the output square wave has a 50:50 mark/space ratio. The type of capacitor used for C1 should have good stability with a low temperature coefficient (e.g. ceramic). The temperature characteristics of D1 ensure that the output square wave is maintained at all levels of output load and

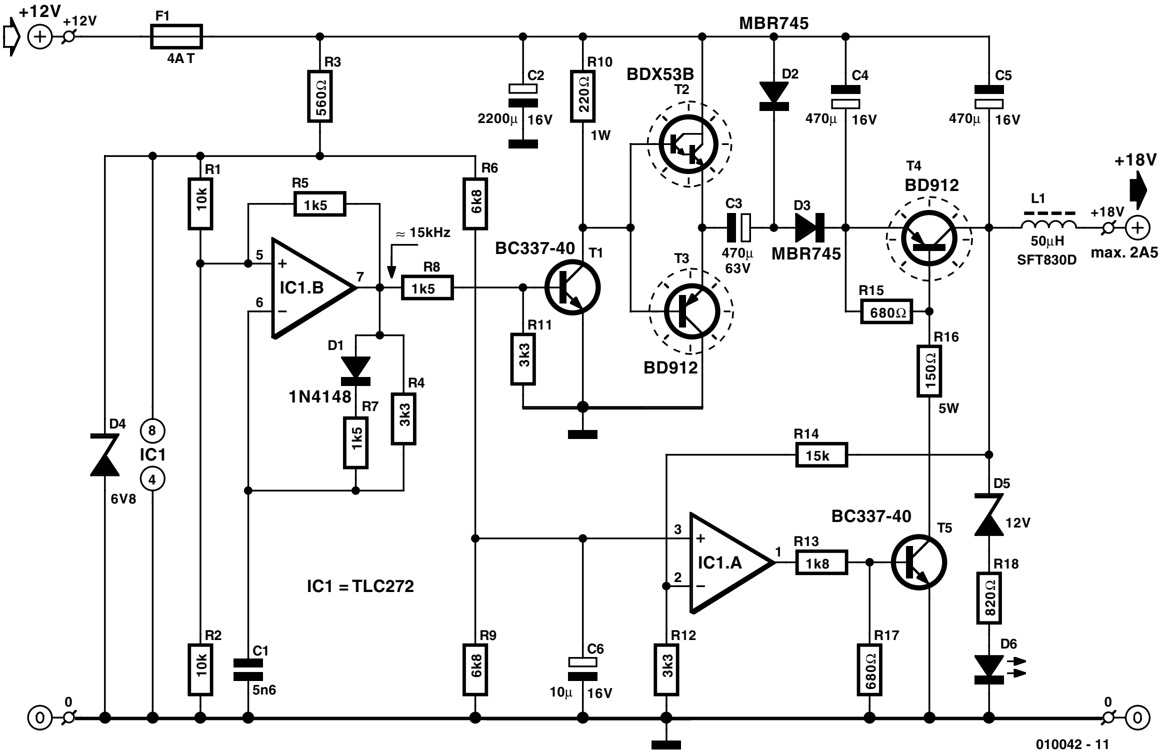


Figure 1. The adapter circuit diagram.

circuit heating. The square wave output from IC1.B switches T2 and T3 alternately. When T3 is conducting C3 charges up to 12 V via D2. When T3 stops conducting and T2 is switched on the negative end of C3 is suddenly connected to the +12 V supply. The charge in C3 cannot change instantly, so when the negative end of C3 steps up by 12 V the positive end must also step up. The voltage on the positive end of C3 will be 'pumped up' to around twice the supply voltage. In practice, losses in the diodes and transistors mean that it will always be slightly less than twice the supply voltage. Schottky diodes are used here to reduce the forward voltage drop. D3 rectifies the voltage and C4 stores it. Capacitor C3 must be able to transfer the total output current so it's important to use a good quality device here. Choose either the 'S+M' from the B41010 series (designed for use in switched mode power supplies) or the LL from the B41588 series of electrolytic capacitors both from Siemens. Certainly you cannot expect the same performance if you fit a bargain basement 'no name' capacitor. The output voltage regulation is performed by op-amp IC1.A The voltage at the collector of T4 is sensed by a potential divider formed by R14 and R12 and compared in IC1.A with the reference voltage formed by R6, R9 and zener diode D4. The output voltage level is set by the value of R14 (see **Figure 2**), 15 kΩ giving an output of approximately 19 V. The output ripple performance at full load is shown in **Figure 3.**

Increasing the value of capacitor C6 will mean that the reference voltage rises more slowly at switch on, thereby giving the adapter output voltage a soft-start characteristic. The switch on delay is visible from LED D6.

The graph in **Figure 4** shows the adapter output voltage at different values of load and input voltage. It can be seen that low input voltages are best avoided. The supply from a cigarette lighter socket is typically 13.2 V at rest and 14.4 V with the engine running, so at high levels of load current the output voltage will only reach 19 V if the car engine is running.

Fan Assistance

During tests it was established that with a loading of 2 A it was not only the three power transistors but also capacitor C3 and Schottky diodes D2 and D3 that were becoming hand hot after a few minutes use. Adequate cooling of these devices is therefore essential. The transistors and Schottky diodes are all packaged in TO220 outlines so it is relatively simple to mount them on a heatsink. If you look at the PCB layout in **Figure 5**, all of these components are mounted along the edge of the PCB so that they can be fixed to (but electrically insulated from!) the metal case. You may notice from the photo of the prototype that the layout has been modified. Additional heatsinks are also necessary along the case sides to improve heat dissipation. It may not so easy to find a heatsink with exactly the right dimensions so it's best to cut two suitable lengths from a standard extruded heatsink profile and fit them to the (unpainted) case sides.

The heat produced in the capacitors is a little more difficult to deal with; you cannot simply bolt on a heatsink. Ventilation slots need to be made in the free PCB area beneath the capacitors to allow air circulation (watch out for the tracks), and a small fan is mounted in the case lid for ventilation. The lid has a 30-mm flat area suitable for mounting the 25?25?10 mm 12 V fan. It should be centred over IC1 and slots or holes cut into the lid and narrow side of the case to allow adequate air circulation. Modern fans produce very little noise and at 30 dB(A) this is not much more

COMPONENTS LIST

Resistors:
R1,R2 = 10kΩ
R3 = 560Ω
R4,R11,R12 = 3kΩ3
R5,R7,R8 = 1kΩ5
R6,R9 = 6kΩ8
R10 = 220Ω, 1W
R13 = 1kΩ8
R14 = 15kΩ
R15,R17 = 680Ω
R16 = 150Ω, 5W
R18 = 820Ω

Capacitors:
C1 = 5nF6
C2 = 2200µF 16V axial
C3 = 470µF 63V axial *
C4,C5 = 470µF 16V radial
C6 = 10µF 16V

Semiconductors:
D1 = 1N4148
D2,D3 = MBR745
D4 = zener diode 6V8 0.4W
D5 = zener diode 12V 0.4W
D6 = LED, high efficiency
IC1 = TLC272CP
T1,T5 = BC337-40
T2 = BDX53B
T3,T4 = BD912

Miscellaneous:
F1 = fuse, 4A, time lag, with PCB mount holder
L1 = 50µH 3A suppressor coil (SFT830D, Conrad Electronics #534412)
Metal enclosure, size 119×65×39 mm
2 heatsinks
12V miniature fan (Conrad Electronics #532614)

* see text

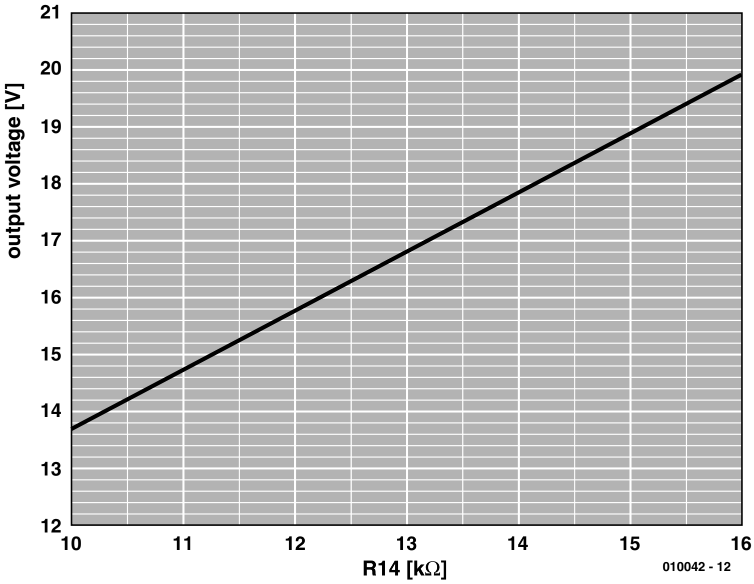


Figure 2. Resistor R14 sets the output voltage.

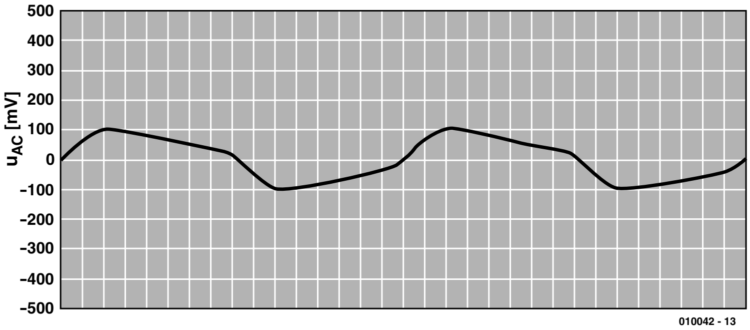


Figure 3. ±100 mV output ripple at full load.

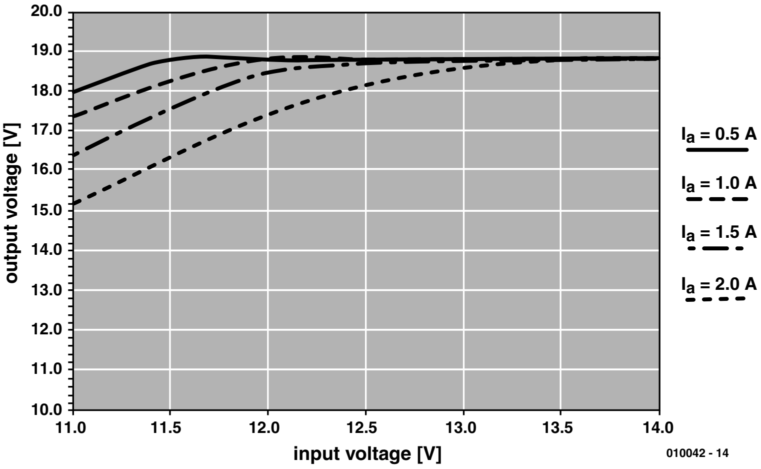


Figure 4. The adapter output load characteristics.

than a whisper. A disadvantage of this solution is the current drawn by the fan. It consumes 70 mA thereby jacking-up the quiescent current of the adapter to 145 mA. This figure is small and once charged there should be no fear of the adapter draining the car battery overnight.

The circuit diagram does not show the fan but it should be connected to the PCB between an earth track and the +12 V input track after fuse F1.

Fitting components to the PCB (**Figure 5**) should not cause any difficulty provided you are careful and double-check anything you are unsure of. Inductor L1 is a standard component available from many outlets. To give it extra rigidity it is a good idea to fix it to the PCB with a generous blob of silicon adhesive after it has been soldered in place.

Mechanical fixing of the PCB into the case is more important for mobile equipment because of the increased risk of accidental knocks and bumps. Allow adequate spacing between the tracks running along the edge of the PCB and the inside of the case and to be really sure it is a good idea to fix thin insulating strips of phenolic resin (Pertinax/Bakelite) along the inside of the case.

The spacing under the PCB should be no greater than 5 mm otherwise the tops of the TO220 packages and the inductor will be too close to the lid.

The input and output cabling can be attached to the PCB using solder pins. The cables should have a cross sectional area in the order of 1.5 mm^2 and strain relief grommets should be fitted to the entrance and exit holes in the case. It is better to use the adapter in unfused cigarette lighter sockets because the fuse gives an additional voltage drop at the input to the adapter, better still fit a good quality accessory socket on the dashboard for connection of the adapter.

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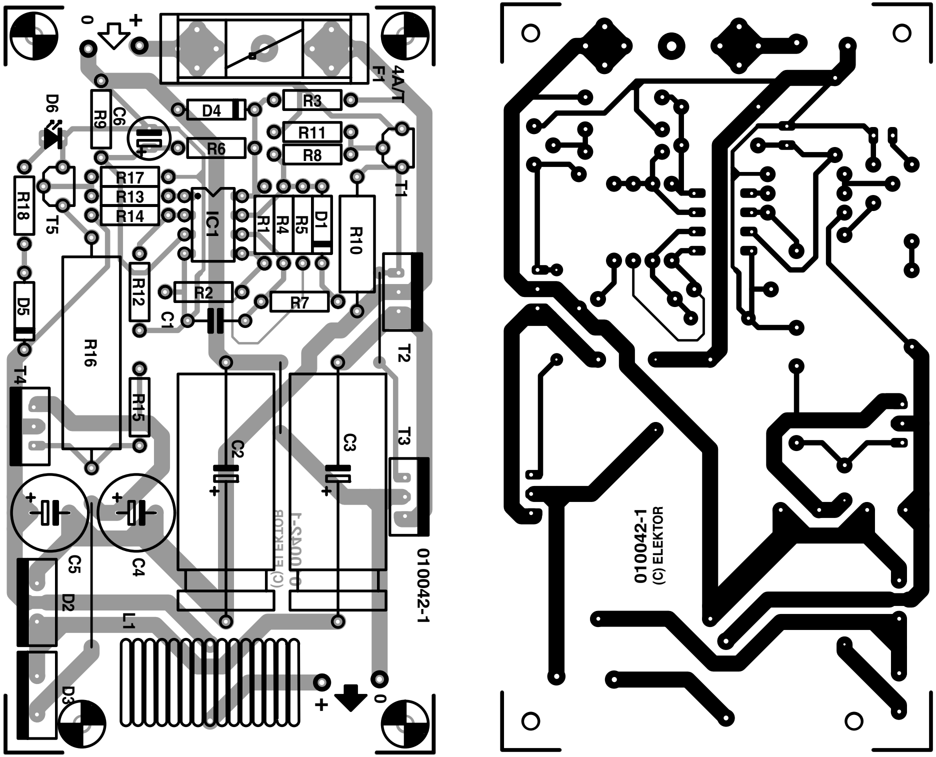

Figure 5. The PCB with two small heatsinks (board not available ready-made).